WAVETEK

MODEL 859
PROGRAMMABLE
PULSE GENERATOR

INTRODUCTION MANUAL

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The Model 859 is a high performance 50 MHz pulse generator designed to meet or exceed both your bench top and ATE system requirements. Its optional second channel increases your versatility by operating almost independently of the first channel.

Wavetek has been recognized for years for its experience in pulse generators as well as a leader in programmable instrumentation. The Model 859 is the positive outgrowth of these years of experience, offering the latest of features as well as superior technical performance.

Key performance features including 20V peak output on pulses from 0.5 Hz to 50 MHz with a Time Interval Mode for pulses to as slow as 9,999 seconds. The instrument has excellent data entry and editing flexibilities with a fully descriptive front panel display. The 859 even offers stored memory for 25 test setups to save time in recalling frequently used settings.

The following sections introduce the Model 859, its data entry, editing, displays, GPIB programming and hints as to enhancing these features to maximize your benefits. A section is also included to review pulse parameters, their terminology and the pulse aberrations associated with various typical pulse applications.

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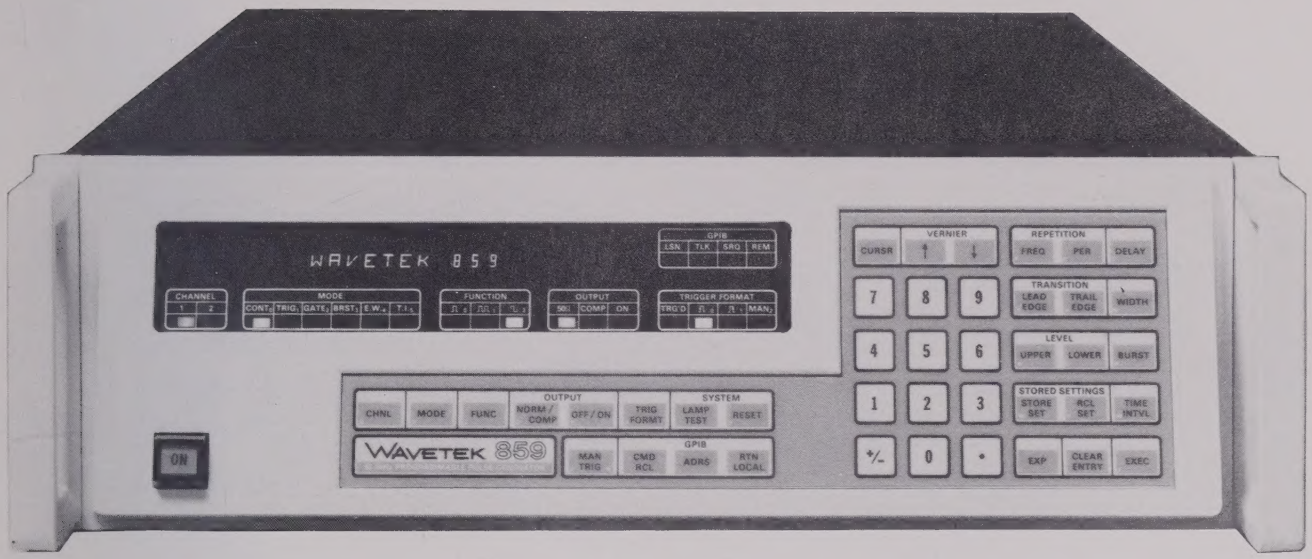
PROGRAMMABLE
PULSE GENERATOR



KEY FEATURES

- 0.5 Hz to 50 MHz Frequency Range
- 20V Peak Pulse into 50Ω Termination
- 5 ns to 25 ms Transition Times
- <2% Timing Accuracy
- <5% Amplitude and Transition Time Accuracy
- Burst Operation to 10,000 Pulses
- Automatic Adjustment for Interdependent Functions
- Second Output Channel Option
- GPIB Programming Standard
- 25 Store/Recall Front Panel Settings
- Complement Output
- Compact 5¼ Inch Full Rack Size
- Ease of Programming
- External Width and Time Internal Modes

CONTENTS

	PAGE
KEY FEATURES AND BENEFITS	1
MANUAL CONTROL AND SET-UP	3
FRONT PANEL CONTROL AND DISPLAY	10
REAR PANEL CONNECTIONS AND SWITCHES	13
859 GPIB PROGRAMMING	15
AIDS IN 859 OPERATION	31
APPENDIX A	33
APPENDIX B	35
APPENDIX C	37

KEY FEATURES AND BENEFITS

FREQUENCY

The 859 offers a full 0.5 Hz to 50 MHz frequency capability to meet virtually all needs. Further, the repetition rate may also be entered in terms of period (P = 1/F) as a time saving asset in data entry. The repetition clock is digitally corrected to track tightly across the full frequency range without the need for any recalibration.

FREE FORMAT

All numerical entries may be made in fixed decimal, floating point, scientific notation or any convenient combinations of these. The microprocessor performs all range selections, round-offs, error checking and parameter interdependent compensations. The parameters may be entered in any order and executed immediately or loaded for a subsequent output at a later time.

MODE VERSATILITY

The popular continuous, triggered and gated modes are standard on the 859. Also standard is a burst counter mode to 10,000 counts, an external width mode for improving external pulse waveshapes, and a time internal mode for single pulses to 9,999 seconds.

STORED SETTINGS

The battery backed-up 25 stored settings are controlled from both front panel and remote control and provide the user with a quick recall of complete setups for both channels almost effortlessly. The stored settings may be recalled individually or in rapid succession for both bench top and ATE requirements. Since pulse generator setups frequently take several keystroke entries (or long programming strings), the stored settings save valuable time and unnecessary labor for the operator/programmer.

GPIB PROGRAMMING

The 859 includes optically isolated GPIB programming as standard. The implementation is consistent with IEEE 488-1978. The interface is buffered permitting a very fast handshake and temporary storage of command while the rest of the bus is allowed to continue with its tasks. The microprocessor handles all the programming information within milliseconds and applies it to the pulse generation circuits upon receipt of the EXECute command. The 859's GPIB interface is just as flexible as the front panel control. The free format acceptance of data eases the programmers task considerably over all other pulse sources of its kind available.

As an aid to the programmer, each of the 859's front panel parameter keys is identified with an ASCII character—this is the character code used by the programmer. In addition, should the programmer decide to manually setup the instrument to the desired configuration, the 859 has a learn mode which dumps all of the channel 1 and 2 settings back into the computer. Another feature is the CMD RCL which is a buffer holding the last 36 programming character entries. Although the display is only 16 characters, the vernier control expands the display to read the remainder of the 36 character codes. This feature is also useful for reading GPIB commands of the 859 and even read the GPIB commands of any desired instrument on the bus.

DUAL CHANNEL

The standard 859 offers a single output channel with provisions for a second channel within the same chassis. A precalibrated second channel may be installed and then be fully operational and back in your system in five minutes. The channels are completely independent except for operating frequency and mode. The delays, widths, amplitudes, functions and transition times for each channel do not interact. Should a dual channel 859 be used as a single channel instrument, an inhibit function turns off the unused channel.

ERROR CHECKING

In creating a pulse waveshape, historically it has been very easy for the programmer to get pulse width, transition time, delays and period to conflict, giving an invalid condition. The oscilloscope doesn't always help since an invalid pulse waveshape is usually unintelligible by this point. However, microprocessor based 859 not only detects conflicts, it indicates the channel involved. The 859 execute feature permits several parameter changes to be entered before final error

checks are made. This minimizes transient nuisance errors and lost entries. The 859 immediately rejects an out of capability error and notifies the operator/programmer via the front panel or SRQ line as appropriate. The 859 implementation of error checking is more flexible and supportive to the operator/programmer than any other programmable pulse source in its class

UNWRITTEN SPEC

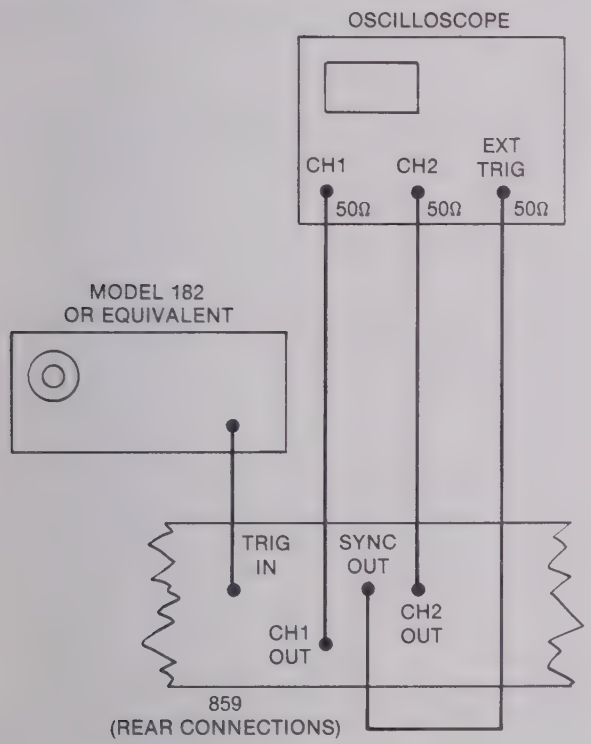
The 859 is designed for top performance and flexibility with emphasis on human engineering. The 859's ease of familiarization and GPIB programming makes it readily suitable to on-line operation usually within minutes of uncrating. A user not already familiar with pulse generators usually finds the 859's interactive display most valuable in improving his own programming capabilities. The free numerical and parameter entry format eliminates the operators task of range selections and mental calculations which the microprocessor performs with ease.

In excerising the front panel, you notice the 859 does not accept impossible entries (eg. FREQ = 0Hz). However, the 859 does permit 'overranging' and operation outside of normal specifications in many cases. Thus, the user finds himself with a high performance pulse generator with the extra flexibility of stretching its spec'd capabilities just a little farther (even though the instrument may not be perfectly linear at these out of spec extremes).

MANUAL CONTROL AND SETUP

SETUP

The setup shown here is used to exercise the various features of the 859 operation. Should your particular instrument be a single channel unit (no option - 001), the second channel of the oscilloscope may be used to display the 859's input trigger output clock or sync.



NOTE: For proper operation, the output 50Ω coax should be terminated in a precision 50Ω load.

The following sections assume the operator will start with stored setting 7 as described on page 4 or that the operator is already moderately familiar with the 859 pulse generator.

POWER UP MODE

When the ac power is applied to the Model 859, the instrument wakes up with the two output channels safely turned off. During the first one or two seconds, the power supplies stabilize and the microprocessor starts its internal checks. While the front panel displays 'SELF TEST', the microprocessor verifies that its own firmware and hardware are in good working order. All ROM's are checked and summed and the RAM's are exercised through special patterns to verify that their read/write, storage and addressing capabilities are operating properly.

Upon the successful conclusion of self-test, the front panel displays 'WAVETEK 859'. The output is still off and the microprocessor sets up the instrument to a convenient starting point of a 1 kilohertz square wave at 1 Vp-p. The instrument goes through this wake-up sequence every time power is turned on or when an ac line power dropout glitch occurs. Since the instrument powers up with the outputs safely turned off, both the 859 and the rest of the system are protected from unexpected signal levels.

To connect the output, press output OFF/ON, 1, EXEC. If the channel 1 LED is lit, the output relay for channel 1 closes and the oscilloscope displays the wake-up square wave on the CRT. To turn on the output for Channel 2, press CHNL, 2, output OFF/ON, 1, EXEC. The status may be inspected from the front panel display at any time by merely pressing the appropriate front panel functional key. This feature allows you to set up your instrument without the need for an external oscilloscope. The output of the 859 is ready to go the moment the execute key is pressed.

Display upon wake-up (2nd channel, when selected, displays a ⎍ function).

= EXECUTE
CHANNEL 1 *(LED LIT)*
OUTPUT ON *(LED LIT)*
SIGNAL APPEARS ON SCOPE.

CHNL | 2 | OUTPUT OFF/ON | 1 | EXEC

= EXECUTE
CHANNEL 2 *(LED LIT)*
OUTPUT ON *(LED LIT)*
SIGNAL APPEARS ON SCOPE

NOTE: The channel 2 output waveform is a very narrow (10 ns) pulse while channel 1 output is a square wave.

CHNL = CHNL 2 SELECTED

CHNL | 1 | CHNL = CHNL 1 SELECTED

OUTPUT OFF/ON = OUTPUT ON (1)

FREQ = FREQ 1 KHz

STORED SETTINGS

Take advantage of the 859's internally stored settings. Each setting consists of two channels worth of complete parameters and they are all backed up by an internal rechargeable battery. Recall time is in just a few milliseconds from either GPIB or front panel. The stored settings feature benefits you greatly during familiarization with the 859 by quickly generating basic pulse waveshapes and later as an aid in recovering from a multiple conflict error state. To check if any stored settings are already present, press stored settings RCL SET, 1, EXEC. The stored settings for location 1 is recalled and outputted immediately or RCL SET ERROR is displayed if no stored setting is available at this location. The vernier ↑ and ↓ numerical increment keys may also be used.

RCL SET | 1 | EXEC =
- EXECUTE
  OUTPUT CHANGES IF STORED SETTING PRESENT
  OR
- RCL SET ERROR
  IF STORED SETTING NOT PRESENT

RCL SET | ↑ = NR 1 RECALLED
NR 2 RECALLED
NR 3 RECALLED
.
.
.
NR 25 RECALLED
CAN'T RECALL
(USE ↓ VERNIER)

(PRESS REPEATEDLY OR HOLD TO INCREMENT)

When using the ↑ and ↓ vernier, EXEC is implied. Further, any not assigned stored settings are automatically skipped over.

NOTE: Stored setting 7 from the factory contains a convenient starting/return point for use with these introductory sections. The following paragraph re-stores setting 7 should it have been erased or edited.

To store the setting for the two channels at any time, the 859 is set up for the desired test and then press stored settings STOR SET followed by a numerical value from 1 to 25. For the following example, use store set 7. If several settings are to be stored, it is not necesary to include the EXEC after each stored setting. The microprocessor automatically inserts an EXEC at the first parameter entry after the store set numerical location. The EXEC is only necessary at the very end of several STORE SET entries.

MODE	0		THESE PARAMETERS ARE INDEPENDENT OF CHANNEL.
TRIG FORMT	2		
Repetition PER	100 EXP-6		
BURST	1		
Time INTVL	20 EXP-6		
Channel	1	2	
FUNC	0	0	
Output NORM/COMP	0	0	
Output OFF/ON	1	1	
Delay	5 EXP-6	5 EXP-6	
Transition LEAD EDGE	1 EXP-6	1 EXP-6	
Transition TRAIL EDGE	1 EXP-6	1 EXP-6	
WIDTH	30 EXP-6	20 EXP-6	
LEVEL UPPER	5	5	
LEVEL LOWER	0	0	

Upon completing the instrument's setup, press:

STORE SET | 7 | EXEC = EXECUTE

To verify the battery backup—turn instrument AC power off. In a few seconds, or weeks later, turn AC power on and then:

RCL SET 7 EXEC = EXECUTE

Verify instrument settings by pressing the appropriate keys.

MODE = MODE CONT (0)

FUNC = FUNC SINGLE (0)

ETC.

To edit a stored setting. Just make the necessary parameter changes and store at the same memory location or another one. The old data is written over automatically. To erase a stored setting, press stored setting STORE SET, followed by a minus number of the setting to be erased, and EXEC.

The microprocessor checks for data errors and valid memory address upon storing a set of parameters. In the retrieval of data, these checks are repeated. By making these checks in the store sequence, the operator may verify his entries as they are entered. This is much more convenient than waiting until after all the entries are made. Should any errors or conflicts be found either on storage or recall, they are indicated on the front panel. One of the important user flexibilities of the 859 is the ability to store instrument setups which are "out of spec'd" performance yet still quite valuable to the user. The 859 does accept certain cases of conflicting interacting parameters. The 859 does not accept any "out of capability" error entries.

RCL SET 7 EXEC = *STORED SETTINGS FROM LOCATION 7 CALLED IN AND EXECUTED*

STORE SET 8 EXEC = *SETTINGS COPIED INTO MEMORY LOCATION 8.*

STORE SET +/- 8 EXEC = *STORED SETTING LOCATION 8 ERASED*

RCL SET 8 EXEC = RCL SET ERROR

Stored settings may be recalled very quickly either manually via the ↑ and ↓ vernier controls or via the remote GET mode. This fast GPIB sequencing through the stored settings is covered in the programming section of this manual.

CHANNEL SELECTION

The 859 is a standard one channel instrument with an optional (option 001) second channel available. To verify if a second channel is installed, press CHAN, 2, EXEC. The channel select 2 led lit indicates the 2nd channel parameters are displayed and may be edited. An error display indicates no optional 2nd channel is installed.

CHNL 2 EXEC CHNL

= CHANNEL 2 SELECTED

The two channels are completely independent except for a shared repetition (frequency/period) circuit and operational mode (continuous, triggered, gated, external width, time interval) selection. The trigger format, burst counter and time interval counter are part of the operational mode circuitry. To operate a two channel 859 as a single channel instrument, the unused channel may be inhibited (killed) via the FUNCtion setting. The unused channel output is turned off and error checking is suspended to this channel. Either channel may be inhibited or both. This feature saves a considerable amount of time (and frustration) when only that one output channel is desired.

CHNL 2 FUNC 3 EXEC

= *FUNCTION DISPLAY IS DARK. SCOPE SHOWS NO OUTPUT CHAN. 2.*

While a channel is inhibited, it may accept new programming parameters but the FUNCtion must be changed and executed before an output is permitted.

CHNL 2 FUNC 2 EXEC

= *SQUAREWAVE APPEARS ON SCOPE.*

MODE

The 859 offers extra versatility as a pulse generator by offering a total of six operational modes. The mode selection is common to both channels and includes the trigger format, burst counter and time interval width. To change mode, press MODE, followed by a numerical entry and EXEC.

MODE 1 EXEC

= EXECUTE
MODE TRIG *(LED LIT)*
SCOPE SIGNAL DISAPPEARS

Code	Mode
0	Continuous
1	Triggered
2	Gated
3	Burst Count
4	External Width
5	Time Interval

Mode Selection

CONTINUOUS (0) Basic pulse generator repeating FUNCtion at repetition rate selected.

TRIGGERED (1) Generator is quiescent until a manual, rear panel, or GPIB command enters the instrument and enables one output pulse (two if double pulse function) at the selected waveshape, transition times, levels, width and delay on each of the two channels.

GATED (2) Similar to triggered mode except generator runs continuously while incoming gate signal is above preset trigger level. All waveforms started during the input gate are allowed to complete and avoid partial waveform distortion.

BURST COUNT (3) An incoming trigger starts the repetition clock and generates a continuous output of pulses at the repetition rate selected (frequency). The number of output pulses is limited to the count predetermined by the burst counter. A new trigger is required to repeat the sequence. Maximum burst count is 10,000.

EXTERNAL WIDTH (4) Any external signal, regardless of transition times, pulse widths, repetition rates or delays are reconstructed to operator determined levels and transition times. The incoming signal may be from raw radar, modem, word generator or even another pulse source. The important width of the incoming signal is preserved by proper adjustment of the trigger level threshold. The width and period setting of the 859 are not used since these are obtained from the external signal.

TIME INTERVAL (5) Combines the use of the repetition rate generator with the burst counter to provide a precise single pulse capability from as short as 20 ns to as long as 9,999 sec (2.78 hours). A single incoming trigger starts the time interval counter. Accuracy for the long pulse is the same as for the regular time base (2%).

FUNCTION

There are three waveshapes available per channel, there are useful outputs while the fourth is a no output (inhibit). To select a function press FUNC, a numerical entry from 0 to 3 and EXEC.

Code	Function
0	Single Pulse
1	Double Pulse
2	Squarewave
3	Inhibit (kill) No Output

Function Selection

The start of the pulse is delayed from time zero (sync out) by the delay entry. The spacing for the second pulse of the double pulse waveform is determined by this delay. In the inhibit function, all function LED's are dark. The inhibited (C3) channel may accept new settings but the output relay remains disconnected until the function code is changed (CO→C2).

FUNC 2 EXEC FUNC

= FUNC SQUARE (2)
50% DUTY CYCLE PULSE ON SCOPE.

OUTPUT CONTROL

Each output channel may be independently complemented and each output channel may have its output relay disconnected. The 859's complement is a true complement in which the upper and lower levels are reversed. It is not necessary to complement your output pulse when the width duty cycle exceeds 50%. To complement a given channel's output, press NORM/COMP, 1, EXEC.

= COMPLEMENTED (1)
SCOPE DISPLAY INVERTS

To return to normal:

= NORMAL (0)
SCOPE NORMAL

The output relay OFF/ON is similar: 0 for OFF, 1 for ON.

The wakeup state and reset of the 859 opens the output relay for each channel. The internal 50Ω load is automatically selected (no manual control) for the low level pulses (<10V p-p) while the 50Ω load is deselected for higher level pulses. The 50Ω internal load is sometimes referred to as a backmatch load.

The 859 output stage operates in a current mode, as opposed to a voltage output, and thus requires a precision 50Ω termination at the user load. As with any current mode source, the output may NOT operate into an open circuit since the current has infinite resistance across which to develop a voltage. *Rule of thumb:* When using a pulse generator, be sure your coax and load are good to at least 10 times the generator's maximum frequency.

> *CAUTION: Avoid high duty cycles and high amplitudes unless your load easily handles the 859's 8 watts output per channel (20V p-p into 50Ω).*

TRIGGERING

The 859 triggers on external BNC input signal, front panel pressing of the MAN TRIG KEY and by GPIB ASCII 'J' or GET command. A trigger via the BNC requires the incoming level to be passing through the threshold level as set on the rear panel of the instrument. A successful trigger or gate from any source appears as a lit TRG'D led on the TRIGGER FORMAT display.

Code	Trigger Format	
0		Ascending Slope
1		Descending Slope
2	Man	Front Panel or GPIB

Trigger Format Selection

To trigger the instrument from the front panel, select the MANual format by pressing TRIG FORMT, 2, EXEC. Each time the MAN TRIG key is pressed, the TRG'D led is momentarily lit. If the GATE or E.W. mode is selected, the TRG'D led remains lit for the duration of the MAN TRIG key being pressed.

= EXECUTE
SCOPE OUTPUT IS QUIESCENT

= GATE ON
TRG'D *(LED LIT)*
SCOPE HAS PULSES ONLY WHEN 'MAN TRIG' IS PRESSED (USE INTERNAL SCOPE TRIGGER)

REPETITION RATE

For operator convenience, the repetition rate may be entered in FREQuency or PERiod (P = 1/F). The internal microprocessor makes all the internal conversions from period to frequency. There are NO range settings to be concerned with when entering data and the 859 accepts a free-formatted entry of numbers. This is any combination of fixed or floating point numerical entries, leading or trailing zeros and the + and − signs of scientific notation. The microprocessor even rounds off to the correct number of significant digits and displays in operator convenient sec, msec, usec, Hz, kHz, etc. To enter a FREQuency, press FREQ, followed by a numerical entry from 0.5 Hz to 50 MHz and EXEC.

= FREQ. 1.23 KHz

= 813 μSEC

DELAY

The time between the SYNC out and the main output for a given channel is setable from 0 ns to 0.999 seconds. The time between corresponding 0% points of double pulse function is also set with the delay parameter. To set the delay, press DELAY, followed by a numerical entry and EXEC.

= DELAY 1 nSEC

TRANSITION TIME

The leading and trailing edges transition times are defined between their 10% and 90% points. This is consistant with good engineering textbook and practices. There is no interaction between transition times and pulse width nor pulse amplitude. The 859's microprocessor is working hard to prevent these interactions. To change either transition time press transition LEAD EDGE or TRAIL EDGE, a numerical entry of or 4 nsec to 25 msec and EXEC.

= LD EDGE 5 μSEC

There is no range selection to be made by the programmer since the microprocessor automatically optimizes the internal selection as the transition time entries are made. Since the leading and trailing edge circuits do share a common range capacitor, transition time ratios (LE/TE and TE/LE) should not exceed approx. 50:1. Beyond this ratio, the timing accuracy drops off.

As a programming aid to save steps in entering the fastest transition times, the instrument accepts 0 as a valid entry and then defaults to 4 ns - the fastest the transition circuits may respond.

= TR EDGE 4 nSEC

WIDTH

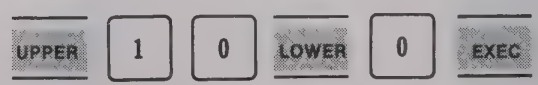
The pulse width is measured at the 50% transition points of the pulse, not at the top of the pulse, nor from corners of the transition points. The width is independent of amplitude and the other pulse parameters. To enter a value for width on a given channel, press WIDTH, followed by a numerical entry between 10 ns and 0.999 seconds and EXEC.

= WIDTH 10 μSEC

The width parameter is not used in the external width nor time interval modes.

AMPLITUDE LEVEL

The peak voltage of the pulse waveforms are defined by the UPPER and LOWER levels for the top and bottom of the waveforms respectively. The pulse level does not interact with any of the other pulse parameters. To enter a value for pulse level, press level UPPER or LOWER, followed by a numerical value and EXEC.



= **EXECUTE**
10 Vp-p PULSE WAVEFORM ON SCOPE

UPPER = UPPER AMPL 10 V

LOWER = LOWR AMPL 0 V

The output should always be terminated into a precision 50Ω load which is easily capable of handling the output power of the 859 ($P = E^2/R \times$ duty cycle = $(20)^2/50 \times 100 = 8$ watts max). A few other guidelines apply to output levels:

UL ≥ LL (Otherwise use complement)
20Vpp ≥ UL-LL ≥ 40mVpp
+20V ≥ UL ≥ −12V
−20V ≤ LL ≤ +12V

The internal 50Ω backmatch is automatically switched in or out as determined by the microprocessor firmware. This advantage saves the operator time and programming effort.

BURST COUNT

The burst count mode permits up to 10,000 output pulses (20,000 if double pulse) for a single input trigger. The burst count is common to both channels. Once the burst counter has been triggered (started), it should be permitted to completely count out and reset. To redefine the burst counter, press BURST, followed by a numerical entry and EXEC.

BURST 1 EXP 3 EXEC BURST

= BURST COUNT 1000

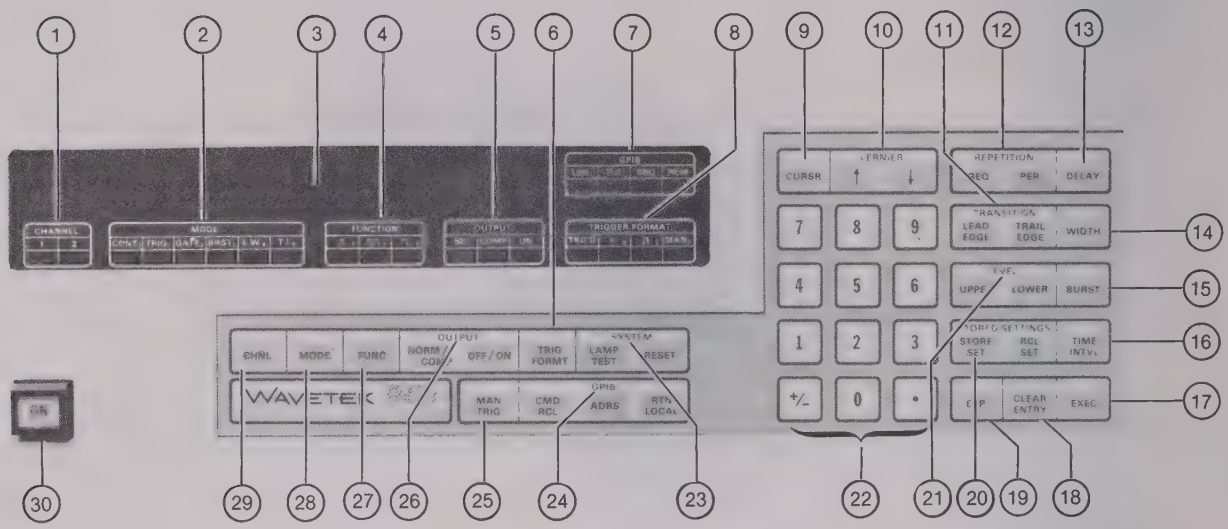
TIME INTERVAL

The time interval mode is a single output pulse from 20 ns to 9,999 sec duration. The delay, width and period parameters are not used in this mode. Time interval is common to both channels and uses portions of the burst counter and repetition clock to obtain very accurate long duration pulses. To enter a pulse duration, press TIME INTVL, followed by a numerical entry and EXEC.

TIME INTVL 1 0 0 EXEC TIME INTVL

= TI INT 100 Sec

FRONT PANEL CONTROLS AND DISPLAY



1 **CHANNEL DISPLAY.** Identifies which of two channels parameters are currently displayed or available for edit.

2 **MODE DISPLAY.** Identifies current operational mode for instrument (both channels share mode).

3 **DISPLAY.** 16 character readout with an additional 20 characters available via the vernier controls. Advises operator of instrument self-test, parameters, errors, parameter conflicts, vernier editing and GPIB address. Also used to display the CMD RCL programming strings for the 859 or to monitor strings for other bus instruments

4 **FUNCTION DISPLAY.** Identifies which of three output waveshapes available for a given channel. If all three function LED's are dark then a no output (or kill) is selected for that channel.

5 **OUTPUT DISPLAY.** Indicates the output stage status for a given channel. The 50Ω LED indicates (via pulse level settings) that the output is backmatched. The COMPlement indicates inverted output. The "ON" indicates the position of the output mechanical relay.

6 **TRIG FORMT (K).** Parameter identifies the triggering and gating edge of incoming BNC signals or whether manual/GPIB triggers and gates are to be used.

7 **GPIB DISPLAY.** Indicates the status of the 859 on the bus.

8 **TRIGGER FORMAT DISPLAY.** The "TRG'D" LED indicates the presence of a trigger/gate/external width mode signal from any external source. The ⎍ and ⎍̄ LEDS indicate the desired transition of an external BNC input. The "MAN" LED is used for both front panel and GPIB inputs.

9 **CURSOR.** Display edit. Permits rapid editing of numerical display. The cursor appears as a blinking digit. When pressed, the blinking cursor moves one decade to the left.

10 **VERNIER ↑ and ↓.** Action edit. Used frequently with the cursor to increment or decrement the value of selected digit. Automatic overflow, underflow and implied execute. May be used to shift right or left on display when used with CMD RCL or error/conflict displays.

11 **TRANSITION LE/TE (U, V).** Parameters define the pulse transition times (10% to 90%) of leading edge and trailing edge.

12 **REPETITION FREQ/PER (F,S).** Parameters define the frequency or period (P = 1/F) in terms most convenient to the operator/programmer.

13 **DELAY (L).** Parameter for setting the length of time (0 → .999s) between the start of the sync pulse and 0% point of the leading edge of the main output pulse. In double pulse mode, one pulse starts coincident with the start of the sync pulse while the delay is used to set the start (0% point) of the second pulse of the main output.

14 **WIDTH (N).** Parameter for setting the number of seconds (10ns →.999s) of width on a pulse as measured at the 50% amplitude points.

15 **BURST (R).** Parameter for entering into a register the desired burst count of output pulses for an incoming burst trigger. Burst count is 10,000 maximum (20,000 double pulse).

16 **TIME INTVL (W).** Parameter to define the precise width of the pulse when in the time interval mode. The normal repetition rate controls are inoperative in this mode.

17 **EXEC (I).** Action key. Causes all the entered settings to be error/conflict checked then transferred to the output circuits. This permits a complete setup to be sent to the output stage with NO errors or output interim aberrations. The VERNIER has an implied execute to save pushbutton steps.

18 **CLEAR ENTRY.** Action key for operator to correct front panel numerical entries.

19 **EXP (E).** Numerical multiplier setting to select the power to 10 following a numeric entry. Both +/− entries accepted.

20 **STORE/RCL STORED SETTINGS (M,Y).** Complete (2 channels) instrument settings are stored in memory locations 1 thru 25. A minus sign (-) followed by a numerical location erases the settings from that memory cell. A previously stored setting may be recalled at any time. EXEC is not automatic.

21 **UPPER/LOWER LEVEL (A, D).** Settings from top of pulse and bottom of pulse. Maximum is ±10V for either setting, 20V p-p max combined. Use the complement for LL > UL.

22 **NUMERICAL KEYBOARD.** Free format data entry allows both floating point and scientific (exponential) notation. Used with other keys to enter data or retrieve information. Microprocessor round off as required.

23 **SYSTEM LAMP TEST/RESET (Z).** Action keys. Lamp test is for LED display. Reset returns both channels to a convenient starting point with both outputs safely off.

24 **GPIB CMD RCL/ADRS/RTN LOCAL.** Action keys.

CMD RCL is used principally by the instrument programmer. By setting up a test from the front panel and then pressing the CMD RCL key, the last 32 character instructions to the instrument are displayed on the front panel. The display is in the precise format for programming the GPIB ASCII string. The CMD RCL key, likewise, will display the programming string as received from the controller via the GPIB, making the 859 a useful GPIB system troubleshooting aid.

ADRS displays the GPIB device number, listen address and talk address as set by the rocker switches on the rear panel. This feature precludes writing the address on the front cover or fiddle with logical unit assignment lookup tables.

RTN LOCAL permits the operator to take the instrument off GPIB control (REM dark) and change parameter settings. A GPIB local lockout command (LLO) overrides the RTN LOCAL key logic and inhibits its operations, providing a remotely controlled security feature.

25 **MAN TRIG (J, H).** Action key for sending a trigger (J) each time the key is pressed. In gated and external width modes, the pressing is a gate on (J) while release is a gate off (H). For front panel key triggering or GPIB triggering, the trigger format "MAN" led is lit.

26 **OUTPUT NORM/COMP OFF/ON (O,P).** Parameters define the state of the output signal for a given channel.

Code	Output
O 0	Normal output
O 1	Complimented (UL/LL reversed)
P 0	Output Off
P 1	Output On

Output Selection

27 FUNC (C). Parameter selects one of the three basic output pulses or inhibit for a given channel.

Code	Function
0	Single pulse
1	Double pulse
2	Squarewave
3	Inhibit output and error checking

Function Selection

28 MODE (B). Setting selects one of six basic modes of operation common to both channels.

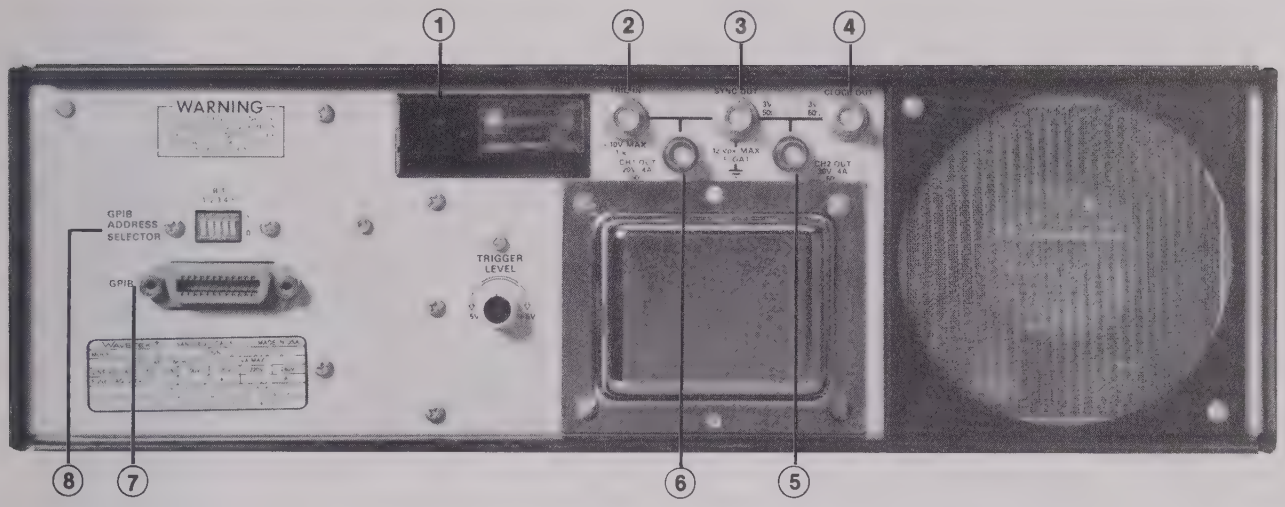
Code	Mode
0	Continuous
1	Triggered
2	Gated
3	Burst Counted
4	External Width
5	Time Interval

Mode Selection

29 CHNL (G). Setting selects which of two channels to be displayed or receive programming edits. If no second channel option is installed, only channel one is a valid entry. The channel number does not require repeating each time new parameter settings are made, but only when a different channel is desired.

30 OFF/ON. Alternate action power switch. All power is removed from the instrument back to the input side of the transformer for your safety. There are no "standby" circuits required in your Model 859.

REAR PANEL CONNECTIONS AND SWITCHES



1 **POWER INPUT.** Prime ac power enters at this point. Line fusing and line voltage selection is made behind the plastic slide cover. The power input conforms to the UL1244 Component Standards.

2 **TRIG IN.** Accepts incoming trigger and gate signals for all non-continuous modes. The trigger point is set by the TRIGGER LEVEL adjustment. A 10 ns minimum pulse width is necessary for valid triggering. Trigger format selects positive going or negative going slope edge. Input impedance is in approx. 1KΩ.

3 **SYNC OUT.** Sometimes referred to as time zero output, is a 0 to 2.2V (TTL) signal at the start of delay time. If zero delay is programmed, the main output 0% point and SYNC OUT positive going pulse are coincident. To minimize reflections, the SYNC OUTPUT should be terminated into 50Ω.

4 **CLOCK OUT.** Provides a 0 to 2.2V (TTL) signal the programmed frequency rate. The clock output differs for each of the modes. To minimize reflections, the clock output should be terminated into 50Ω.

5 **CH1 OUT, CH2 OUT.** The main output waveforms for the two channels are available at these BNC's and both have identical features and capabilities. Each of the outputs is available from −20V to +20V to a maximum of 20V p-p in this 40V window. The main outputs are operating in a current mode and require an external 50Ω load for proper performance.

6 **TRIGGER LEVEL.** Adjustable threshold level determines voltage at which the instrument triggers upon any arbitrary input signal. Range is −5 to +5V. Trigger level is not remotely programmable but trigger slope (⨍, ⨏) is set either by front panel or GPIB.

7 **GPIB ADDRESS SELECTOR** Switches. The GPIB address is entered in binary fashion via these five rocker switches. Bit 1 is the LSB. To change the GPIB address, press the proper combination of rocker switches. By pressing the GPIB ADRS key on the front panel, the display will indicate the new address. The front panel ADRS key cannot change the GPIB address.

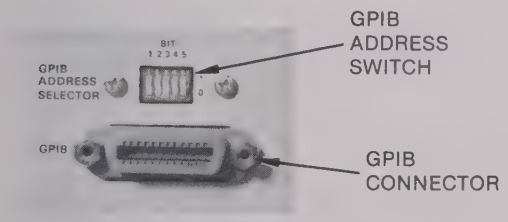
8. **GPIB Connector.** The GPIB cable connection is made at this point. The 859 conforms to the IEEE Standard 488-1978. The GPIB connection is standard, providing proper impedance loading and clearances for cable stacking in any conventional bus pattern. The 859 is optically isolated in both talker and listener modes, which aids in minimizing both system and signal ground loop problems. To "unlock" the front panel keyboard when in remote, it is not necessary to disconnect the GPIB cable; instead, use the RTN LOCAL front panel key.

859 GPIB PROGRAMMING

The Model 859 high performance programmable pulse generator is as easy to program on the bench as it is on an automated system. The extra efforts and flexibilities designed into the microprocessor firmware benefits the operator/programmer through ease of data entry, error checking, and even automatic program character coding. Many of the same operating flexibilities of the other Wavetek microprocessor based programmables all found in the Model 859.

The manual setup or programming of any pulse generator requires more effort than setup of a conventional function generator. Pulse waveshape and timing frequency interact in such a manner to present error conditions. The Wavetek 859 does not change the laws of physics to permit these sometimes impossible situations, but does allow the operator/programmer to perform setups with great flexibility. The 859 settings can be changed without concern about order of entry or formatting to accomodate the instrument. Any real conflicts are well described by the instrument display not just error coded one at a time. Program flexibility and error description are advantages of the 859 which relieve a considerable burden of pulse generator programming complexity.

Should more information on the GPIB be desired, ask for a copy of Wavetek's *Introduction to the GPIB*. This guide is more detailed as to the bus transactions and Wavetek's implementation of the bus.



GPIB Interface

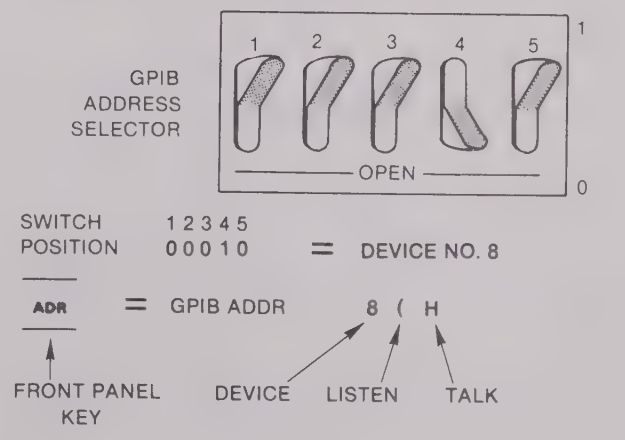
GPIB CONNECTIONS

The GPIB I/O rear panel connection consists of an Amphenol 57-10240 (or equivalent) connector. This is in accordance with the IEEE standard and allows any GPIB cable to be connected at this point. As with all of the Wavetek GPIB programmables, the interface is optically isolated from the rest of the instrument. This eliminates any ground loops caused by program control lines.

GPIB ADDRESS

The 859 bus address is selected with rear panel rocker switches. These five switches each set a digit of a binary number and permit a range of address selection from decimal 0 to 30. Note that switch 5 is the most significant bit and switch 1 the least significant bit. To verify the rocker switch GPIB address, press the front panel ADRS key. The front panel display indicates the decimal address and ASCII listen and talk characters. Possible addresses and their switch settings are listed in appendix A.

The talk and listen addresses are sent via the controller using bits 6 and 7, respectively. Most controllers are formatted to accept the decimal device number as the GPIB address. Check your controller programming manual to see whether your controller requires a decimal address, ASCII character or some variation of these.



GPIB Address

Listen and Talk Formats

The typical listen and talk formats for a Model 859 on the bus with a decimal address of 8, areas follows:

Program for the HP 9825 (HPL Language)

Listen

wrt 702,"F100P1%T5I"	The 7 selects the HP 9825's GPIB interface port. The 08 is the 859 decimal address. The programming string is within the quotes.

Talk

red 708,B$	The 859 talks via the GPIB and returns data to the B$ string within the controller.

Program for the HP 9830 (BASIC Language)

Listen

CMD "?U (","F100P1%T5I"	The ? tells all instruments to unlisten. U is the HP 9830's GPIB interface port. (is the ASCII equivalent listen address of decimal 8.
or	
CMD "?U (OUTPUT (13,*)"F",F,"I"	The 13 is the GPIB interface port. The * is a format assignment for data. The "F" and "I" are ASCII string data. The F (no quotes) is the variable of the formatted data sent to the 859.

Talk

CMD "?5H"	The ? is unlisten. 5 is the controller's listen address. H is the 859's ASCII talk address equivalent of decimal 8.

Program for the HP 21MX (RTE BASIC)

Listen

PRINT #24,"F100P1T5I"	The address 24 is determined by the sum of logical unit assignment of the computer I/O (16 in this case), plus the decimal address (8) of the 859. For details, consult your computer system EQT table.

Talk

READ #24,B$	The 859 talks via the GPIB and returns data to the B$ string in the computer.

Program for the Tektronix 4051/4052 (TEK BASIC)

Listen

PRINT @8,32:"F100P1%T5I"	The 8 is the 859's decimal address. The 32 inhibits the sending of the secondary address (secondary command) which the 859 does not use. The 859's second channel is addressed via a channel code(G) which is part of the regular string.

Talk

INPUT @8:B$	The 859 talks via the GPIB and returns data to the B$ string in the controller.

Program for the PET computer (BASIC)

Early in the Program, Assign Files

OPEN 2,40 OPEN 3,72	The 859 bus addresses are stored in files. File 2 is opened for the listen address (8 + 32) and file 3 is opened for the talk address (8 + 64).

Listen

PRINT #2,"F100P1%T5%X13I"	The 2 indicates file 2, which contains the listener address as defined in the OPEN statement. The % X 13 defines the 859 terminator as CR.

Talk

INPUT #3,B$	The 859 talks via the GPIB and returns data to the B$ string in the computer.

BASIC COMMAND STRUCTURE

The Model 859 is programmed by sending ASCII coded characters (refer to appendix B) to the microprocessor via one of the two possible input ports (keyboard or GPIB). If input characters are present on more than one input port, they are read first from the GPIB and then from the keyboard. Thus, if the GPIB port is continuously supplied with characters, then no characters will ever be read from the keyboard. Further the keyboard is inhibited when the 859 is placed in remote.

Characters used to program the 859 are divided into classes:

1. **Alphabetic characters —** the characters **A** through **Z,** (except **E**.) and the % character. The % character is used in front of an alphabetic character to select an alternate set of actions or commands. It must directly precede the alphabetic character with no intervening characters of any kind. For example, **T** recalls the next stored setting, **%T** selects the talk message resonse, but **%** **T**(where is a space character) recalls the next stored setting, not talk message response, because a space character was placed between the % and the **T**. Alphabetic characters are generated from the keyboard by pressing the labelled action and parameter keys. The characters generated by such keys are printed in the lower left-hand corner of the key.

2. **Numeric characters —** The characters 0 through 9, E, −, decimal point (.).

3. **Special character —** quote (').

4. **Terminator character —** Initially the ASCII line feed character (LF). This can be changed by programming.

5. **Nonprogramming characters —** Any character not in one of the previously described classes. They have no effect on programming and may be interspersed freely among programming characters except after % (refer to item 1).

The alphabetic characters are used to select either actions or parameters. An action is a sequence of events which happens when the character which selects it is programmed or the key that selects it is pressed. There is no need for a numerical suffix. A programming setting has a character (and a key) plus a numeric value which controls some aspect of the instrument's operation.

Alphabetic Characters Used in Model 859

ASCII Character	Keyboard Key	Action(A) Setting(s)	Comments
A*	LEVEL UPPER	S	Upper amplitude
B	MODE	S	Mode of operation
C*	FUNC	S	Waveform
D*	LEVEL LOWER	S	Lower amplitude
F	REPETITION FREQ	S	Repetition rate of waveform
G	CHNL	S	Channel 1 or (optional) 2
H	MAN TRIG (Release)	A	Gate reset
I	EXEC	A	Execute
J	MAN TRIG (Push)	A	Manual trigger
K	TRIG FORMT	S	Trigger format
L*	DELAY	S	Pulse delay
M	STORE SET	S	Store setting
N*	WIDTH	S	Pulse width
O*	OUTPUT NORM/COMP	S	Normal or complemented pulse
P*	OUTPUT OFF/ON	S	Output off or on
R	BURST	S	Number of pulses in burst
S	REPETITION PER	S	Pulse period (reciprocal of frequency)
T	——	A	Next stored setting
U*	TRANSITION LEAD EDGE	S	Pulse leading edge duration
V*	TRANSITION TRAIL EDGE	S	Pulse trailing edge duration
W	TIME INTVL	S	Time interval
X	——	A	Previous stored setting
Y	RCL SET	S	Recall stored setting
Z	SYSTEM RESET	A	Return to power-up setting
%G	——	S	GET mode of operation
%Q	——	S	Service request
%T	——	S	Talk message
%X	——	S	Terminator select

*This parameter's code or value can differ between channels of two channel instruments.

To program an action, simply program the proper alphabetic character from either enabled port. The action will then take place.To examine the current value of a parameter, simply program the proper alphabetic character from either input port. The currect value will then be displayed on the front panel. This occurs whether or not the instrument is enabled. If the character programmed does not correspond to a legal parameter in the instrument, nothing happens.

The numeric characters are used to program new parameter values. To change a parameter value, first program the alphabetic character which selects the desired parameter (F = frequency,etc.). Next, program the new value using numeric characters. Any sequence of characters which gives the new value is acceptable. For example, all of the sequences in the Value Programming table will cause the value 100 to be programmed.

The numbers to the left of the **E** are the mantissa; the digits to the right (only two are allowed) are the exponent. The result value is the mantissa times 10 to the exponent power.

Numeric Characters Used

ASCII Character	Keyboard Key	Function
0	0	Numeric digit
1	1	Numeric digit
2	2	Numeric digit
3	3	Numeric digit
4	4	Numeric digit
5	5	Numeric digit
6	6	Numeric digit
7	7	Numeric digit
8	8	Numeric digit
9	9	Numeric digit
.	.	Decimal point
–	+/–	Toggle sign
E	EXP	Indicates multiplication by 10 raised to a power

Only one decimal point and one **E** (keyboard EXP) are allowed per number; additional ones are ignored. The sign toggle character may appear any number of times. It causes the sign of the mantissa (if **E** has not been programmed) or the exponent (if **E** has been pro-

grammed) to be reversed (if negative, then positive, and vice versa) each time it appears. Any number of nonprogramming characters may be interspersed with the numeric characters, as they have no effect.

Examples of Value Programming

ASCII	Keyboard	Standard Notation
100	100	100
0100	0100	100 (leading zeros are ignored)
1E2	1 EXP 2	1×10^2
.01E4	.01 EXP 4	$.01 \times 10^4$
.01E304	.01 EXP 304	$.01 \times 10^4$ (last two exponent digits only are used)
1000E-1	1000 EXP +/− 1	1000×10^{-1}
1E-2-	1 EXP +/− 2 +/−	1×10^2 (two minus signs cancel)
1E.2	1 EXP .2	1×10^2 (decimal points in exponent are ignored)

With free numerical input, the microprocessor must be told when the last numeric character has been entered so it can evaluate the number. This is done by programming either an alphabetic, special or terminator character. When this is done, the new value is rounded off and tested to see if it is legal value for the setting being changed. If it is legal, the new value is entered into the instrument's scratch pad memory; however, it is not sent to the waveform circuits. That can be done only by programming the I action (EXEC key on the front panel).

When an illegal value is programmed or interdependent parameter errors are detected, an error signal is indicated on the front panel or GPIB. Keyboard errors only are indicated on the front panel display and by a double "beep" of the key tone. For errors made via the GPIB (but not the keyboard), a service request function has been enabled. The controller can than serial poll its instruments to verify that the 859 sent the SRQ and can then inquire as to the nature of the 859 request.

Round Offs

Parameter	Round Off
Upper Level (A) Lower Level (D)	To nearest 10 mV for $-10 \leq UL \leq 10$, $-10 \leq LL \leq 10$, and $UL - LL < 10$; otherwise to nearest 20 mV
Frequency (F)	To 3 digits
Period (S)	(Output to 3 digits)
Delay (L) Width (N)	$< 20\ \mu s$: to nearest ns, $\geq 20\ \mu s$: to 3 digits
Leading Edge (U) Trailing Edge (V)	< 10 ns: to nearest 0.1ns, ≥ 10 ns: to 3 digits
Time Interval (W)	$< 100\ \mu s$:to nearest 20 ns, $\geq 100\ \mu s$:to 4 digits
All Other Parameters	To nearest integer

Class 1 Errors

Class 1 errors are caused by programming values outside the legal limits of the parameter being programmed. For example, programming an upper level of 500 volts will cause a parameter error when the next alpha is programmed. At this time, the 859 disregards the new values and retains the previously programmed values in scratch pad memory.

Class 2 Errors

Class 2 errors are interparameter inconsistencies, such as pulse width greater than pulse period. Tests are made every time an execute (I) is commanded, a setup (**M**) is stored or a vernier key is pressed. Any resulting errors are displayed, and transfers of values are made to waveform circuits or storage regardless of the error indicated. Upon receiving a Group Execute Trigger (refer to paragraph 3.11.7), the 859 programming will be executed without error checking.

In discussing the tests made, the following abbreviations are used:

UL — Upper Level	TE — Trailing Edge
LL — Lower Level	EW — External Width
LE — Leading Edge	TI — Time Interval

Tests always made are:

1. **UL/LL —** Amplitude error if UL − LL > 20V or (|UL| > 10 or |LL| > 10) and UL − LL < 8V or UL − LL < 40 mV.

2. **LE/TE —** Leading/trailing edge error if LE and TE settings are not in the same range.

Additional tests depend on the mode and function parameters. The tests in one of the following groups (A through G) are performed depending on the current value of the mode and function parameters. The particular test group to be used is given by this matrix:

	CONT	TRIG	GATED	BURST	EW	TI
⎍	A	F	A	A	—	D
⎍⎍	B	G	B	B	—	D
⎍	C	E	C	C	—	D

The test groups are listed as follows (an error condition is signalled if the associated condition is true).

A. **W<<** — Width too small if:

0.7 LE > Width − 0.625 TE.

W>> — Width too big if:

Width + 0.625 (LE − TE) ≥ 1.

D>P — Delay longer than period if (for delay <25 ns):

1.03 (Delay + 10 ns) > Period.

or if (for delay ≥ 25 ns):

1.03 (Delay + 20 ns) > Period.

W>P — Width longer than period if:

1.03 ([maximum of 1.3 TE or 8 ns] + Width + 0.625 [LE − TE]) > Period.

B. **W<<** — (Same as in group A.)

D<W — Delay shorter than width if:

1.02 ([maximum of: 1.3 TE or 8 ns] + Width + 0.625 [LE − TE]) > Delay.

D>P — (Same as in group A.)

D+W>P — Sum of delay and width longer than period if:

1.03 ([maximum of: 1.3 TE or 8 ns] + Width + Delay + 0.625 [LE − TE]) > Period.

C. **LE>P** — Leading edge longer than ½ period if:

1.935 LE > Period.

TE>P — Trailing edge longer than ½ period if:

1.935 TE > Period.

D. **TI<LE** — Time interval shorter than leading edge if:

1.1575 LE > TI.

E. **TGSQ** — Triggered square wave is always an error.

F. **W<<** — (Same as in group A.)

W>> — (Same as in group A.)

G. **W<<** — (Same as in group A.)

D<W — (Same as in group B.)

Class 3 Error

Class 3 error occurs if an empty stored setting is retrieved. The error wil be displayed and the state of the 859 remains unchanged from the previously executed program.

Programming Command Summary

Control and Data Names	Model 859 Key	ASCII Character
Clear Numerical Entry	CLEAR ENTRY	None
Activate Keyboard	RTN LOCAL	None
Change of Signs	+/−	−
Decimal point	•	•
0,1,2,...9	0,1,2,...9	0,1,2,...9
Cursor	CURSOR	None
Vernier Up	↑	None
Vernier Down	↓	None
Lamp Test	LAMP TEST	None
Program String	CMD RCL	None
GPIB Address	ADRS	None
Upper Amplitude	LEVEL UPPER	A
Mode	MODE	B
Function	FUNC	C
Lower Amplitude	LEVEL LOWER	D
×10 Multiplier	EXP	E
Frequency	REPETITION FREQ	F
Output Channel	CHNL	G
Gate Reset	MAN TRIG (Release)	H
Execute	EXEC	I
Manual Trigger	MAN TRIG (Press)	J
Trigger Format	TRIG FORMT	K
Delay	DELAY	L
Store Settings	STORE SET	M
Width	WIDTH	N
Output Normal or Complemented	OUTPUT NORM/COMP	O
Output Off or On	OUTPUT OFF/ON	P
Burst Length	BURST	R
Period	REPETITION PER	S
Recall Next Stored Setting	—	T
Leading Edge	TRANSITION LEAD EDGE	U
Trailing Edge	TRANSITION TRAIL EDGE	V
Time Interval	TIME INTVL	W
Recall Previous Stored Setting	—	X
Recall Specific Stored Setting	RCL SET	Y
Instrument Reset	RESET	Z
GET Mode	—	%G
SRQ Enable	—	%Q
Talk Message	—	%T
Terminator Select	—	%X

Output Normal/Complemented (O) Codes

0	Normal
1	Complemented

Function (C) Codes

0	Single Pulse
1	Double Pulse
2	Square Wave
3	Inhibit (no output, no error checking)

Output Off/On (P) Codes

0	Off
1	On

Trigger Format (K) Codes

0	BNC Rear Panel Connector, Rising Edge
1	BNC Rear Panel Connector, Falling Edge
2	Manual Trigger From Front Panel or GPIB

Mode (B) Codes

0	Continuous
1	Triggered
2	Gated
3	Burst
4	External Width
5	Time Interval

SRQ (%Q) Codes

NOTE

This parameter selects the conditions under which the GPIB SRQ signal will be sent by the 859.

0	SRQ not sent
1	SRQ sent if a programming error occurred
2	SRQ sent upon completion of a waveform output in any mode except continuous.
3	SRQ sent if either of the events (1, 2) above occurs

Talk Message (%T) Codes

NOTE

This parameter selects which kind of message the 859 will send when it is addressed as a talker on the GPIB

0	Status of triggered indicator. H 1 is sent if the instrument is outputting a waveform in the triggered, burst or time interval mode. H 0 is sent if not.
1	List of action and parameter selectors which caused programming errors. When read, this list is set to null.
2	Poll byte which would be sent in response to a GPIB serial poll.
3	Value of parameter selected by the most recently programmed selector.
4	State of waveform parameters common to both channels
5	State of waveform parameters in channel 1.
6	State of waveform parameters in channel 2.

Get Mode (%G) Codes

NOTE

This parameter selects which kind of action the 859 will take when it receives a GET command.

0	Execute and trigger upon receipt of GET command (no error checking).
1	Fetch next stored setting, execute and trigger upon receipt of GET command (no error checking).
−1	Fetch previous stored setting, execute and trigger upon receipt of GET command (no error checking).

Number of Significant Digits

Amplitude	Nearest 10 mV for |levels| ≤ 10V p-p floating Nearest 20 mV for |levels| > 10V p-p floating
Frequency	3-digits floating
Period	3-digits floating
Delay/Width	Nearest ns (< μs) floating 3-digits (≥ 20ns) floating
Lead/Trail Edge	Nearest 0.1ns (< 10ns) floating 3-digits (≥ 10ns) floating
Time Interval	Nearest 20ns (< 100μs) floating 4-digits z) ≥ 100μs) floating
All other	1 Integer

Applicable Parameters In Each Mode

Parameter	Mode: Cont B0	Trig B1	Gate B2	Burst B3	EW B4	TI B5
Repetition (F or S)	✓	—	✓	✓	—	—
Transition (U and V)	✓	✓	✓	✓	✓	✓
Level (A and D)	✓	✓	✓	✓	✓	✓
Delay (L)	✓	✓	✓	✓	—	—
Width (N)	✓	✓	✓	✓	—	—
Burst (R)	—	—	—	✓	—	—
Time Interval (W)	—	—	—	—	—	✓
Channel (G)	✓	✓	✓	✓	✓	✓
Trigger Format (K)	—	✓	✓	✓	✓	✓
Func ⎍ (C0)	✓	✓	✓	✓	—	—
Func ⎍⎍ (C1)	✓	✓	✓	✓	—	—
Func ⎍‾ (C2)	✓	—	✓	✓	—	—
Output (O and P)	✓	✓	✓	✓	✓	✓

PROGRAMMING EXAMPLE
USING THE HP 9825A CONTROLLER

To verify the proper hookup and addressing of the 859 to the bus, the next exercise may be performed.

The 859 is given a unit and GPIB address of 8. An HP9825A controller is used with a GPIB address of 7 (7XX).

Enter an EXECUTE after each of the following:

wrt 708
(the GPIB REM LED is lit)

lcl 708
(the GPIB REM LED is dark)

wrt 708, "P1"
(the OUTPUT ON LED is lit but no change to the output circuits)

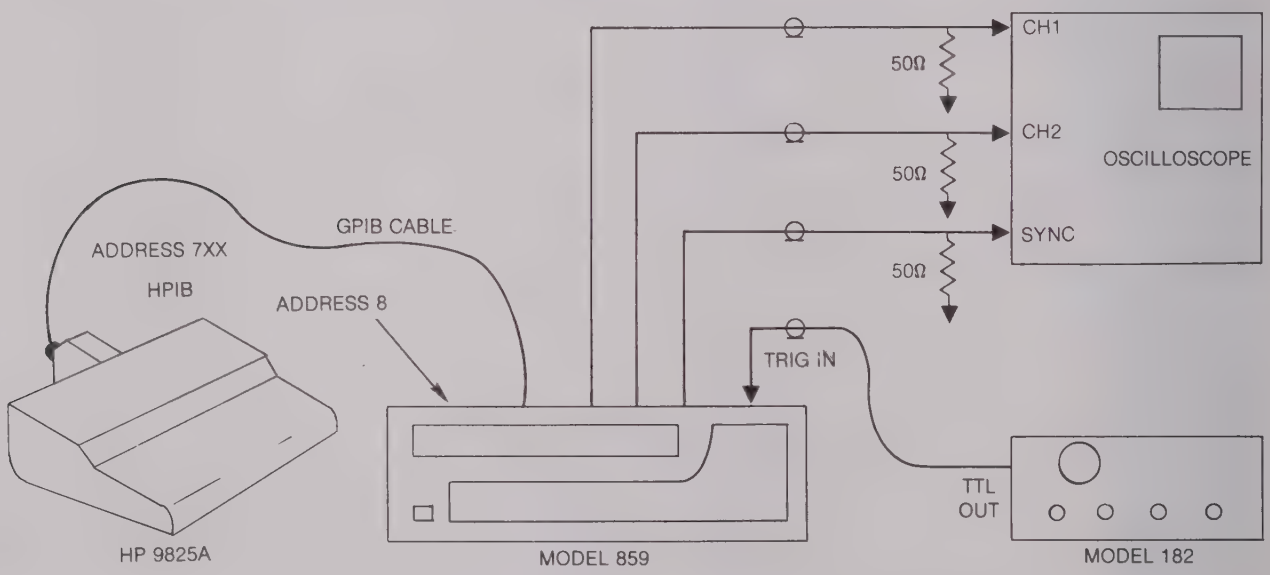
wrt 708 "I"
(A 1kHz, 1Vpp square wave on output BNC)

clr 708
(displays 859 RESET; output is reset)

wrt 708, "A10D-5P1I""
(15 Vpp, 1kHz, square wave output)

In the remainder of this section the left-hand column contains programming characteristics of the various parameters of the Model 859. The right-hand column provides program examples demonstrating these parameters.

The following program uses the instrument setup shown below.



NOTE: THE MODEL 182 PROVIDES A TRIGGER AT APPROXIMATELY 1kHz FOR THE MODEL 859.

Model 859 Setup.

Initialization

The 859's GPIB address is 8 as set by the rear panel rocker switches and verified by the ADRS key on the front panel. The controller refers to the address as "859" hereafter.

The RESET (Z) function saves time and effort when returning the 859 to a known set of starting conditions. The output is disconnected and the 859 otherwise offers a simple squarewave which is an easy starting point for most tests. Refer to table 3-1 of the *859 Instruction Manual* for a listing of the reset parameters.

A short waiting period after a reset or change of several parameters gives all the parameters a chance to settle before the actual test output is required by the UUT. The 859 is probably much faster than the other instruments on the bus.

The free format of the 859 allows very flexible numerical entries. The 'fxd 11' format is more to accommodate the controller than the 859.

```
0: dsp "MODEL
 859 DEMO"
1: "15 September
 79", Bruce
 Gould":
2: dev "859",733
3: ent "HOW MANY
 CHANNELS (1
 or 2)",C
4: "start":
5: wrt "859",
 "ZI"
6: wrt "659",
 "B0G1C0D0P1L0F1
 0E3N20E-6U1E-
 6V1E-6A5D0I"
7: if C=2;wrt
 "859","G2L6P1C2
 U1E-6V1E-6A5D0G
 1I"
```

Frequency/Period

The repetition rate of the 859 is expressed in frequency or period. The repetition rate is always the same for both channels. Frequency is available from 0.5 Hz to 50 MHz. Period is available from 20 ns to 2s. Since period is internally (to the 859) defined as p = 1/f, the 859 microprocessor calculates to the nearest frequency. For longer duration pulses than 0.5s, the time interval mode should be used.

```
8: wait 500
9: wrt "859",
 "'WAVETEK DEMO'
 "
10: wait 2000
11: fxd 11
12: "FREQ":
13: wrt "859",
 "'FREQUENCY'"
14: wait 1000
15: for I=1 to 2
16: for S=1e-4
 to 3e-5 by -1e-
 6
17: wrt "859",
 "S",S
18: trg "859"
19: next S
20: for S=3e-5
 to 1e-4 by 1e-6
21: wrt "859",
 "S",S
22: trg "859"
23: next S
24: next I
```

Delay

The time between the start of the sync pulse to 0° point (start of the leading edge) on the waveform pulse is defined as delay. The delay is also used with double pulse to time the start of one of the pulses from the sync pulse. In double pulse modes that other pulse starts at 'sync' time and the normal pulse is the one that is really delayed in time. Delay is available from 0ns to 999 ms with up to 1ns steps up to 19.999μs.

Although the published specification some minimum reset and maximum percent ranges, these are intended as general statements. Go ahead and overrange these conservative delay specifications with favorable results.

```
25: dsp "DELAY"
26: wait 500
27: wrt "859",
 "'DELAY'"
28: wait 500
29: for I=1 to 2
30: for L=0 to
 5e-5 by 1e-6
31: wrt "859",
 "L",L
32: trg "859"
33: next L
34: for L=9e-5
 to 0 by -1e-6
35: wrt "859",
 "L",L
36: trg "859"
37: next L
38: next I
```

Width

Pulse width is defined as being from the 50% point of the leading edge of the pulse to the 50% point of the trailing edge of the pulse. (As leading and trailing edge transition times are varied, the programmed pulse width is maintained.) This is the same definition as carried by most integrated circuit manufacturers Width is programmable from 10 ns to 1s. Resolution is three digits from 20μs to 999 ms and 1 ns from 10 ns to 19.999μs. Pulse width is limited to 90% of pulse period and a minimum of time determined by leading and trailing edge transition times; e.g., 10 ns for 4 ns transition times. Width programming does not affect output in external width and time interval modes and for the square waveform function.

Similar to the delay splecification, do not feel overly restricted on the pulse width 90% limitation. Either program the 859 beyond its conservative specifications or 'complement' the output.

```
39: dsp "WIDTH"
40: wait 500
41: wrt "859",
 "'WIDTH'"
42: wait 500
43: for I=1 to 2
44: for N=2e-5
 to 9.5e-5 by
 1e-6
45: wrt "859",
 "N",N
46: trg "859"
47: next N
48: for N=9.5e-
 5 to 2e-5 by -
 1e-6
49: wrt "859",
 "N",N
50: trg "859"
51: next N
52: next I
```

Double Pulse

Besides offering a single pulse, a second pulse with identical parameters (except for delay) may be programmed. This second pulse always occurs at time zero (sync time). The maximum number of pulses the 859 can output at a time is still a 50 MHz rate and thus only 25 million double pulses per second.

```
53: dsp "DOUBLE
 PULSE"
54: wrt "859",
 "C1N5E-6L8E-6I"
55: wait 500
```

```
56: wrt "859",
 "'DOUBLE PULSE'
 "
57: wait 500
58: for I=1 to 2
59: for L=8e-6
 to 9.5e-5 by
 1e-6
60: wrt "859",
 "L",L
61: trg "859"
62: next L
63: for L=9.5e-
 5 to 8e-6 by -
 1e-6
64: wrt "859",
 "L",L
65: trg "859"
66: next L
67: next I
68: wrt "859",
 "COI"
69: for N=5e-6
 to 2e-5 by 5e-7
70: wrt "859",
 "N",N
71: trg "859"
72: next N
```

Rise/Fall

The leading and trailing edge transition times (frequently referred to as 'rise/fall' times) are measured at their 10% and 90% points (by convention). The transition times are programmable from 4 ns to 25 ms. While varying transition times, the pulse width remains constant. This is important since certain other pulse generators do vary pulse width as the transition times are changed.

As a programming aid, the 859 accepts leading and trailing edge entries of 0 (zero). This permits a very simple means of programming the fastest transition times of the 859. The instrument defaults to 4ns transition times since this is the fastest the 859 can validly respond.

```
73: dsp "RISE
 FALL"
74: wait 500
75: wrt "859",
 "'RISE/FALL'"
76: wait 500
77: for I=1 to 5
78: for V=1e-6
 to 1.8e-5 by
 1e-6
79: wrt "859",
 "V",V
80: trg "859"
81: next V
82: for V=1.8e-
 5 to 1e-6 by -
 1e-6
83: wrt "859",
 "V",V
84: trg "859"
85: next V
86: next I
87: wait 500
```

```
88: wrt "859",
 "'RISE/FALL'"
89: wait 500
90: for I=1 to 5
91: for U=1e-6
 to 1.8e-5 by
 1e-6
92: wrt '859",
 "U",U
93: trg "859"
94: next U
95: for U=1.8e-
 5 to 1e-6 by -
 1e-6
96: wrt "859",
 "U",U
97: trg "859"
98: next U
99: next I
100: wait 500
101: wrt "859",
 "'RISE/FALL'"
102: wait 500
103: for I=1 to
 5
104: for J=1e-6
 to 9e-6 by 5e-7
105: wrt "859",
 "U",J,"V",J
106: trg "859"
107: next J
108: for J=9e-6
 to 1e-6 by -5e-
 7
109: wrt "859",
 "U",J,"V",J
110: trg "859"
111: next J
112: next I
```

Upper/Lower Levels

The pulse upper and lower levels refer to the amplitude to the top of a pulse from zero and the dc offset of the lower end of a pulse from zero. The lower level is always less than the upper level. The output amplifier is capable of driving a 20V p-p maximum pulse anywhere in a 40V p-p window. The output should always be terminated by a 50Ω load since the 859 is operating in a current (not voltage) mode.

```
113: dsp 'UPPER/
 LOWER LEVEL'
114: wrt "859",
 "G1B0C0D0F1F10E
 3N20E-6R5D0I"
115: wait 500
116: wrt "859",
 "'UPPR/LWR LEVE
 L'"
117: wait 500
```

```
118: for A=.1
 to 10 by .1
119: wrt "859",
 "A",A
120: trg "859"
121: next A
122: for A=10
 to .1 by -.1
123: wrt "859",
 "A",A
124: trg "859"
125: next A
126: wrt "859",
 "A00-.1011"
127: 0→A
128: for D=-.1
 to -10 by -.1
129: wrt "859",
 "D",D
130: if A>0;wrt
 "859","D",-A
131: trg "859"
132: next D
133: for A=.1
 to -8 by -.1
134: wrt "859",
 "A",A
135: trg "859"
136: next A
137: for A=-8
 to 10 by .2
138: wrt "859",
 "A",A+"D",A-2
139: trg "859"
140: next A
```

Burst

The burst mode permits the 859 to output a given number of pulses up to 10,000 (double for double pulse) for each input trigger. This particular program uses an external generator as a trigger source. The pulse train starts upon a trigger at the front panel BNC, rear panel BNC or via the GPIB (J or GET). The duration of the burst is dependent upon the programmed repetition rate and the burst length count.

```
141: dsp "BURST"
142: wrt "859",
 "B3C0008?1E-5M?E
 -6U1E-6V1E-6A5D
 0K0G2A5D0G1K1I"
143: wait 500
144: wrt "859",
 "'BURST'"
145: wait 500
146: for I=1 to
 10
147: for R=1 to
 I
148: wrt "859",
```

```
 "R",R,"I"
149: wait 100
150: next R
151: for R=I to
 1 by -1
152: wrt "859",
 "R",R,"I"
153: wait 100
154: next R
155: next I
```

Stored Settings

The standard 859 offers 25 sets of stored settings (expandable to 100 sets). Internal batteries back up these RAM devices. Each setting includes everything associated with both channels of the instrument. Because of recall speed and program versatility, the stored settings feature are extremely valuable.

The **M** command stores a set of settings into memory while the **Y** command recalls a specific set. This program takes advantage of the next setting/last setting features via the GET mode. The stored settings may be "written over" with new settings when desired or may be deleted completely. The paragraphs of section 3.10 of the *Model 859 Instruction Manual* covers stored settings in depth.

```
156: dsp "STORED
  SETTINGS- CONS
 TANT ENERGY"
157: wrt "859",
 "P100C0B0S150E-
 6J1E-6V1E-6A.5D
 .04N100E-6I"
158: wait 500
159: wrt "859",
 "'STORED SETTIN
 GS'"
160: wait 500
161: 1e-4→N
162: .5→A
163: 5e-5→U
164: 5e-5→V
165: for M=1 to
 6
166: wrt "859",
 "L",abs(7.5e-5-
 .8125*(N/2↑(M-
 1)))
167: wrt "859",
 "N",N/2↑(M-1)
168: wrt "859",
 "U",U/2↑(M-1)/2
169: wrt "859",
 "V",V/2↑(M-1)/2
170: wrt "859",
 "A",A*2↑(M-1)
171: wrt "859",
 "M",M
172: next M
173: wrt "859",
 "G1B0C0O0P1S100
 E-6L5E-6U1E-
 6V1E-6N30E-6A5D
 0R1W20E-6M7I"
174: wrt "859",
```

```
  "G2D0C0P1S100E-
  6L5E-6U1E-6V1E-
  6N20E-6A5D0R1W2
  0E-6M7I"
175: 1→M
176: 6→N
177: gsb 179
178: sto 192
179: for I=1 to
  3
180: for J=M to
  N
181: wrt "859",
  "Y",J
182: trg "859"
183: wait 200
184: next J
185: for J=N-1
  to M+1 by -1
186: wrt "859",
  "Y",J
187: trg "859"
188: wait 200
189: next J
190: next I
191: ret
192: if C#2;sto
  "finish"
193: wrt "859",
  "S1E-4G1B0C0L0M
  1E-5U1E-6V1E-
  6D3P100A5"
194: wrt "859",
  "G2C0L9E-5N1E-
  5U1E-6V1E-6D0P1
  D0A5I"
195: wait 1000
```

Channel 2

The second channel is identical to the first with its own full flexibilities. The only parameters which are shared between the channels are frequency/period and mode.

Should a 2 channel 859 be used in a 1 channel application, the unused channel may be inhibited (killed) from error checking and output. To do this, call up the unused channel and enter function 3 (C3), execute (I) then return to the desired channel.

```
196: wrt "859",
  "'2 CHANNEL
  DEMO'"
197: wait 500
198: for I=1 to
  4
199: for L=0 to
  9e-5 by 5e-6
200: wrt "859",
  "G1L",L,"G2L",
  9e-5-L
201: trg "859"
202: next L
```

```
203: for L=9e-5
 to 0 by -5e-6
204: wrt "859",
 "G1L",L,"G2L",
 9e-5-L
205: trg "859"
206: next L
207: next I
208: wait 500
209: wrt "859",
 "'2 CHANNEL
 DEMO'"
210: wait 500
211: for I=1 to
 4
212: for N=1e-5
 to 9e-5 by 5e-6
213: wrt "859",
 "G1N",N,"G2N",
 N,"L",9e-5-N
214: trg "859"
215: next N
216: for N=9e-5
 to 1e-5 by -5e-
 6
217: wrt "859",
 "G1N",N,"G2N",
 N,"L",9e-5-N
218: trg "859"
219: next N
220: next I
221: gto "finish
 "
222: wrt "859",
 "G1B0C0D0S1B0E-
 6L0N4E-5U5E-
 9V5E-9A5D0I"
223: wrt "859",
 "G2B0C0D0L0N2E-
 5U5E-9V5E-9A5D0
 I"
224: wait 3000
225: wrt "859",
 "G1U1E-5V1E-
 5G2L2E-5N1E-
 5U1E-6V1E-6I"
226: wait 3000
227: wrt "859",
 "G1N2E-5U2E-
 5V1E-6G2C1L0N2E
 -5V2E-5U1E-6I"
228: wait 3000
229: wrt "859",
 "G1N4E-5U1E-
 5V1E-5G2N4E-
 5U1E-5V1E-5I"
230: wait 3000
231: wrt "859",
 "G1S1E-4G2L5E-
 5I"
232: wait 3000
233: wrt "859",
 "G200I"
234: wait 3000
235: wrt "859",
 "G1L5E-6G2L55E-
 6N3E-5I"
236: wait 3000
237: wrt "859",
 "G1L1E-5N2E-
 5G2L6E-5N2E-6I"
238: wait 3000
239: wrt "859",
 "G1L1.5E-5N1E-
 5G2L6.5E-5N1E-
 6I"
240: wait 3000
241: wrt "859",
 "G1S1.8E-4L0N2E
 -5U1E-6V1E-6G2L
 8E-5U1E-6V1E-
 6I"
242: wait 3000
243: wrt "859",
 "G1C1L3E-5G2L0I
 "
244: wait 3000
245: wrt "859",
 "G1U5E-6V5E-6I"
246: wait 3000
247: wrt "859",
 "G2L5E-6I"
248: wait 3000
249: wrt "859",
 "G2L2E-5I"
250: wait 3000
251: wrt "859",
 "G2L3.5E-5I"
252: wait 3000
253: wrt "859",
 "G1C0L0N6.56E-
 5U1E-4G2L1E-
 4N5E-6U.5E-6V.5
 E-6I"
254: wait 3000
255: wrt "859",
 "G2L1L5E-5N4E
 -5U20E-6V20E-
 6I"
256: wait 3000
257: wrt "859",
 "G1L5E-5N4E-
 5U2E-5V2E-5A.5G
 2C0U1N4E-5A0D-
 8I"
258: wait 3000
259: wrt "859",
 "G1A1D0G2A0D-
 4I"
260: wait 3000
261: wrt "859",
 "G1A2D0G2A0D-
 2I"
262: wait 3000
263: wrt "859",
 "G1A4D0G2A0D-
 1I"
264: wait 3000
265: wrt "859",
 "G1A8D0G2A0D-
 .3I"
266: wait 3000
267: "finish":
268: wrt "859",
 "'WIN WITH WAVE
 TEK'"
269: wait 3000
270: gto "start"
*11293
```

AIDS IN 859 OPERATION

- Pre-plan the waveform you will be using. The majority of errors are time related. By ensuring that the sum of the transition times, pulse width and delay are less than the period, few difficulties should be encountered. With the 859's free format entry, it may be less confusing to enter all timing parameters in nsec, in msec or in seconds to avoid mental conversions.

- For repetitive tests in which most, if not all, parameters are known, take advantage of the stored setting feature. The recall time for a complete stored test is much less than that of repeating the complete setup. Both channels are updated in each stored setting.

- Avoid inbetween test output aberrations by executing a complete setup instead of executing several partial setups. The free format control of the 859 permits the programming of a new waveform output for later execution. The output of the 859 does not change when new programming instructions are first received. The instructions are buffered until the execute (I) is received; then the output changes. For example:

  wrt 702, "A5D0"

  Then, the output does not change, since the I has not been received. If subsequent programming is:

  wrt 702, "IA1D-1"

  Then, the first setup is executed and a subsequent setup string (optional) is programmed in for later execution. Note that the output changed only with the I. This program format of executing one setup and loading the next permits true flexibility in the bus. New programming instructions may be sent via the bus during dwell time and thus avoid the critical (time consuming) interval of GPIB transmission just before execution.

- When only one channel of a dual channel instrument is to be used, take advantage of the channel inhibit function. When a channel is inhibited, all error checks on the unused channel are skipped, avoiding unnecessary error indications.

- If speed on the GPIB is premium, program frequency instead of period. The microprocessor in the 859 takes a few extra milliseconds to convert period into frequency.

- Design your computer system to avoid unnecessary time delays. GPIB instruments such as power meters, DVM's and counters tend to be slow on the bus to the point of unnecessarily slowing other bus instruments. In a production line application, several seconds per test may be saved by assigning two GPIB I/O cards, one for slow instruments and another for fast ones such as the 859.

- In large computer systems, it is common to store the software drivers on a disc and call in each overlay package of drivers as required. Since the typical time to seek out and load a new overlay is about 400 milliseconds, a considerable savings of time may be made by consolidating all the bus related drivers into one overlay. Calculator-based systems generally operate without the need for disc resident driver overlays and thus avoid such inherent delays of going back and forth to the external storage device.

- The CMD RCL front panel key allows the operator to manually set up a test and then examine the entire programming string commands on the front panel. The string is in exactly the same format as required for the same setup via the GPIB. The front panel display may also be used to send messages to the operator in lieu of an expensive separate CRT display. A typical test setup of frequency, upper level and lower level appears on the display when CMD RCL is pressed:

  F123E3A5D0I

  The GPIB string for this same task is:

  "F123E3A5D0I"

  A typical operator message is:

  PROBE 1 to TP7

- The rear panel BNC's are isolated from chassis ground, but share a common signal ground. The signal may be floated a maximum of ±42 volts

from the chassis. Use care if one of these BNC shields is floated, since all of the other BNC cables will also assume this new shield potential. This means all other instruments will assume this new potential. The BNC center conductor should never be back biased.

- The output amplifier operates in a current mode as opposed to voltage mode. This means the output expects to see a 50Ω precision load. If no load resistor is present (open circuit), the output is undefined for the higher pulse amplitudes.

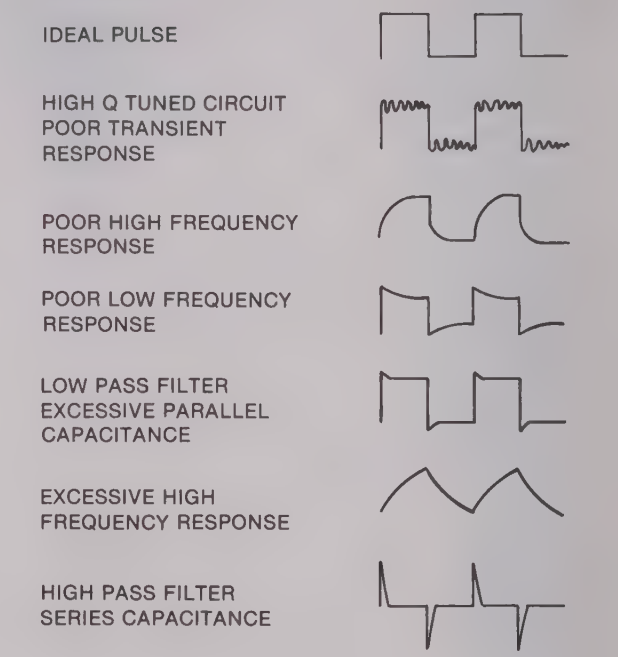
  The output load resistor must be capable of handling the expected levels of the 859. Each channel is capable of delivering 8 watts maximum. The ever popular 2 watt 50Ω load is useless after a few seconds of operation at these high amplitude, high duty cycle outputs.

- The output of the 859 is capable of very high frequency operation with fast transition times and narrow pulses. If viewed on an oscilloscope, the vertical plug-in should have a capability of at least 10 times the maximum frequency square wave being generated. If critical measurements are to be made, a sampling oscilloscope must be used.

- Many oscilloscope inputs as well as user input loads have a high capacitance. This X_C detracts from sharp corners and overall performance of the pulse waveform by changing the matching impedance $X_C = 1/2\pi FC$. The effect of this capacitance may be minimized by using at 10× type attenuator just before the termination load resistor. A 10× attenuator divides the capacitive load component by 10.

- Use equal length coax cables on the outputs. A mere 20 cm (8 in.) of RG 58/U coax equals 1 nsec of delay. The 859's output BNC's are electrically compensated to output at precisely the same time when zero delay is entered. Unequal cable lengths detract from this timing advantage.

- Should our pulse output start to exhibit any one or more of the following waveshapes, check your system for the related causes due to improper loading.


IDEAL PULSE
HIGH Q TUNED CIRCUIT POOR TRANSIENT RESPONSE
POOR HIGH FREQUENCY RESPONSE
POOR LOW FREQUENCY RESPONSE
LOW PASS FILTER EXCESSIVE PARALLEL CAPACITANCE
EXCESSIVE HIGH FREQUENCY RESPONSE
HIGH PASS FILTER SERIES CAPACITANCE

APPENDIX A

GENERAL PURPOSE INTERFACE BUS ADDRESS

Device	Address								
	ASCII		Switch Position					Hexa-decimal	
	Listen	Talk	1	2	3	4	5	Listen	Talk
0	(space)	@	0	0	0	0	0	20	40
1	!	A	1	0	0	0	0	21	41
2	"	B	0	1	0	0	0	22	42
3	#	C	1	1	0	0	0	23	43
4	$	D	0	0	1	0	0	24	44
5	%	E	1	0	1	0	0	25	45
6	&	F	0	1	1	0	0	26	46
7	'	G	1	1	1	0	0	27	47
8	(	H	0	0	0	1	0	28	48
9	)	I	1	0	0	1	0	29	49
10	*	J	0	1	0	1	0	2A	4A
11	+	K	1	1	0	1	0	2B	4B
12	,	L	0	0	1	1	0	2C	4C
13	—	M	1	0	1	1	0	2D	4D
14	•	N	0	1	1	1	0	2E	4E
15	/	O	1	1	1	1	0	2F	4F
16	0	P	0	0	0	0	1	30	50
17	1	Q	1	0	0	0	1	31	51
18	2	R	0	1	0	0	1	32	52
19	3	S	1	1	0	0	1	33	53
20	4	T	0	0	1	0	1	34	54
21	5	U	1	0	1	0	1	35	55
22	6	V	0	1	1	0	1	36	56
23	7	W	1	1	1	0	1	37	57
24	8	X	0	0	0	1	1	38	58
25	9	Y	1	0	0	1	1	39	59
26	:	Z	0	1	0	1	1	3A	5A
27	;	[	1	1	0	1	1	3B	5B
28	<	\	0	0	1	1	1	3C	5C
29	=	]	1	0	1	1	1	3D	5D
30	>	↑	0	1	1	1	1	3E	5E

APPENDIX B

AMERICAN STANDARD CODE FOR INFORMATION INTERCHANGE (ASCII)

b7 b6 b5 / BITS / b4 b3 b2 b1 / column / row	0_0	MSG[1]	0_1	MSG	1_0	MSG	1_1	MSG	2_0	MSG	2_1	MSG	3_0	MSG	3_1	MSG
	0		1		2		3		4		5		6		7	
0 0 0 0 / 0	NUL		DLE		SP	↑	0	↑	@	↑	P	↑	`	↑	p	↑
0 0 0 1 / 1	SOH	GTL	DC1	LLO	!		1		A		Q		a		q	
0 0 1 0 / 2	STX		DC2		"		2		B		R		b		r	
0 0 1 1 / 3	ETX		DC3		#		3		C		S		c		s	
0 1 0 0 / 4	EOT	SDC	DC4	DCL	$		4		D		T		d		t	
0 1 0 1 / 5	ENQ	PPC[3]	NAK	PPU	%		5		E		U		e		u	
0 1 1 0 / 6	ACK		SYN		&		6		F		V		f		v	
0 1 1 1 / 7	BEL		ETB		'		7		G		W		g		w	
1 0 0 0 / 8	BS	GET	CAN	SPE	(		8		H		X		h		x	
1 0 0 1 / 9	HT	TCT	EM	SPD	)		9		I		Y		i		y	
1 0 1 0 / 10	LF		SUB		*		:		J		Z		j		z	
1 0 1 1 / 11	VT		ESC		+		;		K		[		k		{	
1 1 0 0 / 12	FF		FS		,		<		L		\		l		|	
1 1 0 1 / 13	CR		GS		-		=		M		]		m		}	
1 1 1 0 / 14	SO		RS		.		>		N		^		n		~	
1 1 1 1 / 15	SI		US		/	↓	?	UNL	O	↓	_	UNT	o	↓	DEL	↓

MLA ASSIGNED TO DEVICE (LISTEN ADDRESS GROUP, LAG)

MTA ASSIGNED TO DEVICE (TALK ADDRESS GROUP, TAG)

MEANING DEFINED BY PCG CODE (SECONDARY COMMAND GROUP, SCG)

ADDRESSED COMMAND GROUP (ACG)

UNIVERSAL COMMAND GROUP (UCG)

PRIMARY COMMAND GROUP (PCG)

[1]MSG = INTERFACE MESSAGE
[2]b1 = DIO1 . . . b7 = DIO7
[3]REQUIRES SECONDARY COMMAND
[4]DENSE SUBSET (COLUMN 2 THROUGH 5)

DC4	= DCL	Device clear	Universal Command Group
DC1	= LLO	Local lockout	
NAK	= PPU	Parallel poll unconfigure	
EM	= SPD	Serial poll disable	
CAN	= SPE	Serial poll enable	
SOH	= GTL	Go to local	Address Command Group
EOT	= SDC	Selected device clear	
ENQ	= PPC	Parallel poll configure	
BS	= GET	Group execute trigger	
HT	= TCT	Take control	

This ASCII table consoldiates not only the address codes and relationships, but also the bus commands. The GPIB instructions and commands and, for those instruments so equipped, the display and the command recall on the front panel may be analyzed using this table.

APPENDIX C
GLOSSARY OF PULSE TERMS

PULSE TERMS

Amplitude

The maximum absolute peak value of a pulse measured from the baseline and excluding unwanted aberrations or overshot. Measurement points are at 50% of the pulse duration time (pulse high level) and on the baseline (pulse low level) at 50% of the off time (the pulse period minus the pulse duration).

Aberrations

Unwanted deviations or excursions in the pulse shape from an ideal square corner and flat top; namely, overshoot, undershoot or rounding, ringing, and tilt or slope.

Baseline

The quiescent dc voltage reference level of the pulse waveform.

Complementary Pulse

Normal pulse with high and low levels interchanged. Pulse on-time becomes pulse off-time.

Duty Factor

Sometimes referred to as duty cycle. The ratio of pulse duration to period. Duty factory in % = Duration/Period × 100.

Falltime

The time interval, at the pulse trailing edge, for the pulse amplitude to fall from the 90% amplitude level to the 10% amplitude level.

Flatness

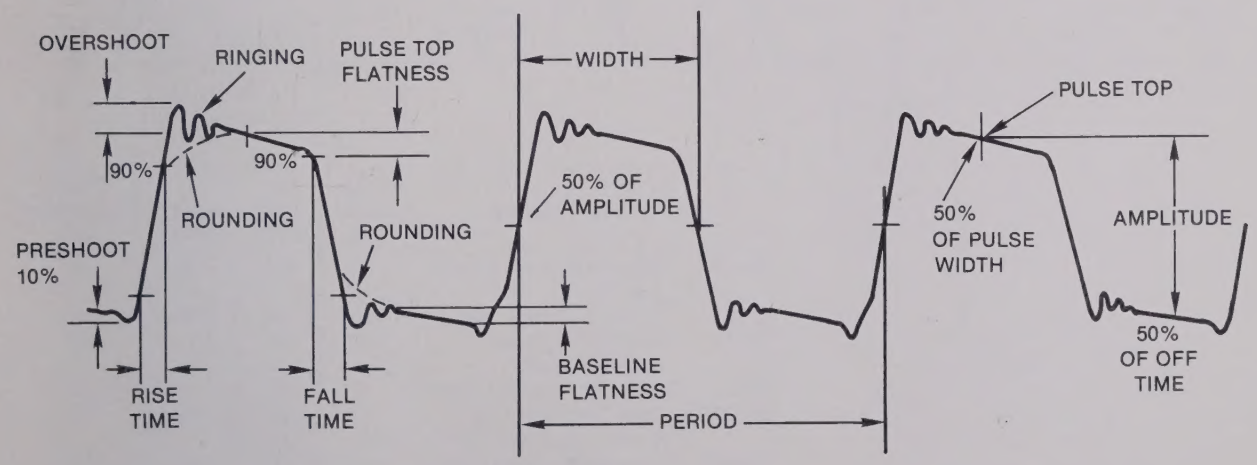
The drop of the pulse top, excluding overshoot, ringing or pulse rounding. Sometimes referred to as tilt or slope.

High Level

The most positive value of a pulse, regardless of unwanted aberrations or overshoot, measured at a point that is located at 50% of the pulse duration.

Low Level

The most negative value of a pulse, regardless of unwanted aberrations or overshoot, measured at a point that is 50% of the off time.



DUTY FACTOR = PULSE DURATION/PULSE PERIOD

Offset

A dc potential of either polarity applied to the waveform to bias the baseline to an amplitude other than zero.

Overshoot

The short term pulse excursion (or transient) above the pulse top or below the baseline, which is simultaneous to the leading or trailing edge of the pulse.

Period

The time interval for a full pulse cycle, inverse of frequency or repetition rate, or the interval between corresponding pulse amplitudes of two consecutive undelayed or delayed pulses. Generally measured between the 50% amplitude levels of two consecutive pulses.

Polarity

The direction from the baseline of the pulse excursion, either positive-going or negative-going.

Preshoot

A transient excursion that precedes the step function. It may be of the same or opposite polarity as the pulse.

Ringing

Periodic aberrations that dampen in time, following overshoot.

Risetime

The time interval for the pulse to rise from the 10% to 90% amplitude levels.

Rounding or Undershoot

The rounding of the pulse corners at the edges of a step function.

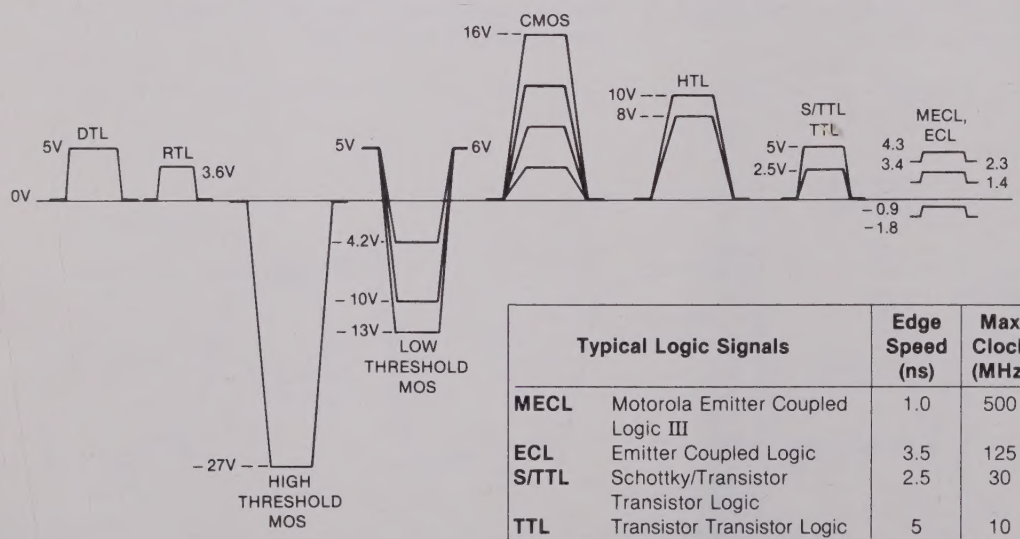
Tilt or Slope

A distortion of an otherwise flat-topped pulse, characterized by either a decline or a rise of the pulse top (see Flatness).

Width

The time interval between the leading and trailing edge 50% pulse amplitude time.

The voltage levels that apply to these logic groups are often vague and ill-defined. CMOS, for example, can be 0 to +16V for some types to +10 for others, etc. The chart below indicates the most common levels encountered.



Typical Logic Signals		Edge Speed (ns)	Max Clock (MHz)	Input Z(kΩ)	Input Capacitance (pF)
MECL	Motorola Emitter Coupled Logic III	1.0	500	2/50	<5
ECL	Emitter Coupled Logic	3.5	125	50	<5
S/TTL	Schottky/Transistor Transistor Logic	2.5	30	4	<15
TTL	Transistor Transistor Logic	5	10	4	<15
DTL/RTL	Diode Transistor Logic/ Resistor Transistor Logic	5	10	300-5	5
CMOS	Complementary Metal Oxide Semiconductor	≤40	<10	>100	5-30
MOS	Metal Oxide Semiconductor	≤25	<10	>100	10
HTL	High-Threshold Logic	≥20	1	>10	10

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